

REMARKS

The subject invention relates to optically pumped semiconductor (OPS) lasers. In these devices, a semiconductor chip is formed with a multi-quantum well gain medium (12) and an attached resonator mirror (14). An external mirror (not shown in the drawings) defines the resonator. The surface of the gain medium is optically pumped to generate laser light.

Continuing efforts are being made to increase the output power of these OPS lasers. As the power levels increase, it becomes more important to remove heat from the gain structure. In the past, it has been known to bond a copper heat sink to the OPS chip to remove heat. To improve heat flow, it has also been known to adhesively bond a diamond heat spreader between the OPS chip and the copper heat sink. Adhesive or solder bonding is simple and inexpensive but has certain problems. First, the solder is not particularly thermally conductive and thus restricts the heat flow from the chip to the heat sink. Further, when heated, the solder can produce stresses between the bonded elements that can alter optical properties and even result in cracks in the chip.

In order to overcome this problem, applicants use an alternate bonding approach. More specifically, applicants directly connect the diamond heat conducting element to the OPS chip using "contact bonding." As set forth in the specification at page 5, line 4, the term contact bonding is intended to define a bond that is "formed without a physical adhesive between the bonded members." This type of bond requires that the elements be very flat and very clean. The two surfaces are then brought into pressure contact. Preferably, the assembled structure is then annealed at elevated temperatures, between 100 – 350 degrees centigrade (see specification at page 10, line 13 for more details). As noted in the specification at page 5, line 6, this bond is comparable to an "optical contact" bond used in the optical industry to form an adhesive free bond between optically transparent solid materials. One skilled in the art would recognize that the subject disclosure is describing a fixed, substantially permanent bond.

In the Office Action, the Examiner rejected claims 1 to 6, 10, 11 and 13 based on the commonly owned patent to Salokatve (6,327,293) in view of the newly cited Bewley patent (6,448,642). Salokatve discloses an optically pumped semiconductor laser structure which is adhesively bonded to a heat sink. The patent to Bewley was cited for its teaching of the use of a pressure bond between a semiconductor laser and a heat sink to reduce thermal resistance. Although Bewley describes his arrangement as a "bond," it is **not** a fixed connection. In fact, at

column 9, line 42, Bewley states "The bond is in no way permanent. When the pressure is removed, the materials separate without any damage to either surface."

The Bewley patent is not particularly clear how one obtains a pressure "bond" that is not permanent. Bewley merely states that "Pressure needed for the pressure bond can be applied in the manner indicated by arrow 23." (Specification, column 3, line 28.) In an attempt to better understand the nature of the Bewley "bond," an article by Bewley was reviewed (IEEE Quantum Electronics 1999 - cited in the original Information Disclosure Statement). Although the IEEE article also failed to disclose the details of the pressure bond, the article does include a citation to an earlier Bewley article which is submitted herewith. This 1999 Bewley article appearing in Applied Physics letters includes essentially the same Figure as the Bewley patent. In addition, Bewley describes his bonding mechanism as follows: "The thermal bond was created solely through the application of pressure, which was exerted from the back by a chisel-pointed screw." (page 1075, left hand column). This description is of course consistent with the cited Bewley patent which states that the "bond" is not permanent.

As can be appreciated, the approach suggested by Bewley could not be easily implemented in a commercial laser system. Moreover, a non-permanent bond could result in failure of the lasers. In contrast, applicants have developed and are claiming a pressure bond of the type comparable to an optical bond. This type of bond relies upon the Van der Waals effect between adjacent molecules to hold the pieces together. It is very difficult to separate two surfaces bonded in such a manner. Applicants have amended the claims to more clearly point out this distinction. Since Bewley fails to disclose a contact bond which creates a substantially fixed connection between the parts, it is respectfully submitted that Bewley cannot overcome the deficiencies of Salokatve in anticipating or rendering obvious applicants' invention.

In the Office Action, the Examiner cited the patent to Zayhowski (5,386,427) for its teaching of a sapphire heat conducting element. Zayhowski relates to a thermally controlled lens that is cooled by a heat sink. Zayhowski merely states that the heat sink is "thermally coupled" to the lens. There is no teaching in Zayhowski that the heat sink should be connected to the lens by a contact bond created by pressure without an adhesive. Accordingly, Zayhowski fails to overcome the deficiencies of the primary references in rendering obvious applicants' invention.

In the Office Action, the Examiner cited the patent to Raymond (6,393,038) for its teaching of a second heat conducting member and a copper heat sink. Raymond does teach the

use of a copper heat sink but the copper heat sink appears to be the only heat conducting member disclosed in Raymond. More importantly, Raymond only discloses "mounting" the OPS chip on the heat sink. There is no teaching in Raymond that this mounting should be a contact bond created by pressure without an adhesive. Accordingly, Raymond fails to overcome the deficiencies of the primary references in rendering obvious applicants' invention.

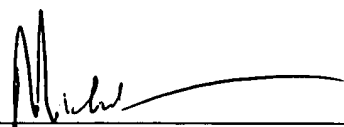
In the Office Action, the Examiner cited the patent to Pinneo (6,919,525) for its teaching of a CVD diamond heat spreader. Pinneo is directed towards semiconductor packaging and discloses positioning a diamond heat spreader between a microprocessor and the package enclosure, which in turn, is connected to a heat sink. Pinneo teaches that the diamond heat spreader can be attached to the microprocessor by brazing, adhesive or solder. In the Figure 5 embodiment of Pinneo, thin sheets of flexible graphite are interposed between the microprocessor and the heat spreader. In order to avoid the use of adhesive bonding and thereby reduce mechanical shear forces, the assembly of Figure 5 is held together with a spring clip. Pinneo fails to teach a contact bond created by pressure without adhesives. Accordingly, Pinneo fails to overcome the deficiencies of the primary references in rendering obvious applicants' invention.

Based on the above, it is respectfully submitted that all of the amended independent claims define patentable subject matter and allowance thereof, along with the claims depending therefrom is respectfully requested.

Respectfully submitted,

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